Sub B1

a lower barrier layer; and

a quantum well layer disposed between the upper barrier layer and the lower barrier layer; and wherein the ions are introduced no closer than 0.5 microns from the upper and lower barrier layers; and

thermally annealing the quantum well structure;

wherein quantum well interdiffusion is induced and the bandgap energy of the quantum well layer is shifted.

A1 concluded

~~2. (Amended) The method of claim 1, wherein~~ the elevated temperature is in the range of from about 200 °C to near the crystal damage temperature.

A2

2. ~~4.~~ (Amended) The method of claim 1, wherein the introducing step creates crystal site vacancies in the quantum well structure at a concentration below $6x10^{19}$ cm^{-3}.

A3

~~13. (Amended)~~ The method of claim 12 wherein the introduced ions are selected from a deep-level ion species group consisting of ~~oxygen, gallium,~~ fluorine, nitrogen, boron and argon.

11. ~~18.~~ (Amended) The method of claim 1 wherein:

the quantum well structure further includes an upper cladding layer disposed above the upper barrier layer; and

the introducing step includes introducing the ions into the upper cladding layer.

A4

12. ~~19.~~ (Amended) The method of claim 1 wherein:

the quantum well structure further includes an upper cladding layer disposed above the upper barrier layer; and

the introducing step includes introducing the ions into the upper cladding layer such that the impurity ions are at least 0.5 micron from the upper barrier layer.

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A5

14. ~~21.~~ (Amended) The method of claim 13 ~~20~~, wherein the thermally annealing step is conducted at a temperature above 600 °C, and wherein the quantum well structure contains InP.

15. ~~22.~~ (Amended) The method of claim 14 ~~21~~, wherein the thermally annealing step is conducted at a temperature above 700 °C, and wherein the quantum well structure contains GaAs.

A6

17. ~~24.~~ (Amended) The method of claim 1, wherein the introducing step employs an implantation dosage of greater than 1×10^{12} cm^{-2}.

A7

20. ~~27.~~ (Amended) The method of claim 1 further comprising, after the introducing step and before the thermal annealing step, depositing a capping layer on an upper surface of the quantum well structure.

21. ~~28.~~ (Amended) The method of claim 1, wherein the quantum well structure further includes a layer doped with a high mobility impurity and is back-spaced by at least 0.1 μm from at least one of the quantum well layer, the upper barrier layer and the lower barrier layer.

A8

24. ~~33.~~ (Amended) The method of claim 1, further comprising the step of:

forming a patterned mask layer over the quantum well structure;

wherein the implanting step includes implanting the ions into a predetermined portion of the quantum well structure, at a temperature in the range of from about 200 °C to about 700 °C, using the patterned mask layer as an implant mask; and

wherein the quantum well interdiffusion is induced and the bandgap energy of the predetermined portion of the quantum well layer is shifted.

A9

25. ~~38.~~ (Amended) The method of claim 24 ~~33~~, wherein the quantum well interdiffusion is induced and the bandgap energy of the predetermined portion of the quantum well structure is shifted with a spatial resolution of less than 3 microns.

A

~~37.~~ ~~47.~~ 36 (Amended) The method of claim ~~36~~ 36 further comprising, during ~~the forming step,~~ forming the patterned mask layer that includes a plurality of patterned mask layer portions, each of the plurality of patterned mask layer portions having a thickness that is different than the thickness of the other patterned mask layer portions, and during the implanting step, implanting ions into predetermined portions of the quantum well structure using the patterned mask layer to control the penetration of ions into the predetermined portions of the quantum well structure.

A10

D. Please add the following new claims:

48. A method for shifting the bandgap energy of a quantum well layer comprising:

introducing ions into a quantum well structure at an elevated temperature and with an implantation energy of no more than 400 KeV, wherein the quantum well structure is formed over a substrate and includes at least:

an upper barrier layer;

a lower barrier layer; and

a quantum well layer disposed between the upper barrier layer and the lower barrier layer; and

thermally annealing the quantum well structure;

wherein quantum well interdiffusion is induced and the bandgap energy of the quantum well layer is shifted.

A11 cont

49. The method of claim 48, wherein the elevated temperature is in the range of from about 200 °C to near the crystal damage temperature.

50. The method of claim 48, wherein the introducing step creates crystal site vacancies in the quantum well structure at a concentration below $6x10^{19}$ cm^{-3}.

51. The method of claim 48 wherein the introduced ions are selected from the deep-level ion species group consisting of oxygen, gallium, fluorine, nitrogen, boron and argon.

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52. The method of claim 48, wherein the quantum well structure further includes an upper cladding layer disposed above the upper barrier layer, and wherein the ions are introduced into the upper cladding layer such that the ions are at least 0.5 micron from the upper barrier layer.

53. The method of claim 48 further comprising, after the introducing step and before the thermal annealing step, depositing a capping layer on an upper surface of the quantum well structure.

54. The method of claim 48, wherein the quantum well structure further includes a layer doped with a high mobility impurity and is back-spaced by at least 0.1 μm from at least one of the quantum well layer, the upper barrier layer and the lower barrier layer.

A11 cont

55. The method of claim 48, further comprising the step of:

forming a patterned mask layer on a quantum well structure, wherein the implanting step includes implanting the ions into a predetermined portion of the quantum well structure using the patterned mask layer as an implant mask, and wherein the quantum well interdiffusion is induced and the bandgap energy of the predetermined portion of the quantum well layer is shifted.

56. The method of claim 55, wherein the patterned mask layer is a patterned stress-inducing mask

57. The method of claim 56, wherein the patterned mask layer is formed of SiO_2.

58. The method of claim 56, wherein the patterned stress-inducing mask layer is formed of a material with a thermal coefficient of expansion that is at least 10 times different than the thermal coefficient of expansion of the substrate.

~~59. The method of claim 56, wherein the stress-inducing patterned mask layer includes a plurality of patterned mask layer portions, each of the plurality of patterned mask layer portions having a thickness that is different than the thickness of the other patterned mask layer portions, and during the implanting step, the ions are implanted into predetermined portions of the quantum well structure using the patterned mask layer to control the penetration of ions into the predetermined portions of the quantum well structure.~~

30. ~~60.~~ A method for shifting the bandgap energy of a quantum well layer comprising:

introducing ions into a quantum well structure at an elevated temperature and with an implant energy of no more than 400 KeV, wherein the quantum well structure is formed over a substrate and includes at least:

an upper barrier layer;

a lower barrier layer; and

a quantum well layer disposed between the upper barrier layer and the lower barrier layer;

All cont

wherein the ions are introduced no closer than 0.5 microns from the upper and lower barrier layers; and

thermally annealing of the quantum well structure to induce quantum well interdiffusion that shifts a bandgap energy of the quantum well layer.

31. ~~61.~~ The method of claim ~~60~~ 30, further comprising the step of:

forming a stress-inducing patterned mask layer on the quantum well structure before the introduction of the ions, wherein the patterned stress-inducing mask layer is formed of a material with a thermal coefficient of expansion that is at least 10 times different than the thermal coefficient of expansion of the substrate.

32. ~~62.~~ The method of claim ~~61~~ 31, wherein the stress-inducing patterned mask layer includes a plurality of patterned mask layer portions, each of the plurality of patterned mask layer portions having a thickness that is different than the thickness of the other patterned mask layer portions, and during the implanting step, the ions are implanted into predetermined portions

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of the quantum well structure using the patterned mask layer to control the penetration of ions into the predetermined portions of the quantum well structure.

33. ~~63~~. The method of claim 1, wherein the ions are introduced into predetermined portions of the quantum well structure with different dosages and/or different implant energies to vary the bandgap energy shifts induced therein by the quantum well interdiffusion.

34. ~~64~~. The method of claim 33 ~~63~~, wherein:

the bandgap shift for one of the quantum well structure predetermined portions is selected to form a passive optical device; and

the bandgap shift for another one of the quantum well structure predetermined portions is selected to form an active optical device.

35. ~~65~~. The method of claim 34 ~~64~~, wherein the passive optical device is an optical waveguide or a multi-mode interference couple, and the active optical device is an optical modulator or an optical amplifier.

A1 cont

36. ~~66~~. The method of claim 35 ~~65~~, wherein the quantum well structure predetermined portions form an optical switch, with optical waveguides connecting a plurality of optical amplifiers to a multi-mode interference couple.

37. ~~67~~. The method of claim ~~48~~, wherein the ions are introduced into predetermined portions of the quantum well structure with different dosages and/or different implant energies to vary the bandgap energy shifts induced therein by the quantum well interdiffusion.

38 ~~68~~. The method of claim 37 ~~67~~, wherein:

the bandgap shift for one of the quantum well structure predetermined portions is selected to form a passive optical device; and

the bandgap shift for another one of the quantum well structure predetermined portions is selected to form an active optical device.

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39. ~~69~~. The method of claim 38 ~~68~~, wherein the passive optical device is an optical waveguide or a multi-mode interference couple, and the active optical device is an optical modulator or an optical amplifier.

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40. ~~70~~. The method of claim 39 ~~69~~, wherein the quantum well structure predetermined portions form an optical switch, with optical waveguides connecting a plurality of optical amplifiers to a multi-mode interference couple.

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